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The Journal of HEREDITY

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SIX LAMBS—A RECORD "LITTER"

(See Page 229)

Education and Eugenics

Do X-Rays Produce an "After-effect?"

Differences in "Siamese" Twins

Dilute Aleurone Color

Body and Mind

VOLUME 22 JULY, 1931 NUMBER 7

The American Genetic Association

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SIAMESE TWINS FROM THE PHILIPPINES

Frontispiece

With their wives, separate identical twins. Siamese twins, being physically joined together, have been regarded as unquestionably originating from a single fertilized ovum. The marked differences between conjoined twins has been a disconcerting fact hard to reconcile with their identical origin.

DIFFERENCES BETWEEN CONJOINED TWINS

In Relation to a General Theory of Twinning

H. H. NEWMAN
University of Chicago

I. Conjoined Twins Not Identical

NO ONE who has examined conjoined twins can have failed to notice how different the two members of a pair are. Photographs of such twins are quite disappointing to the observer, because he expects the component twins to be identical and finds them actually so decidedly different.

To illustrate this point let us look over a few well known cases of the Siamese twin type, all classed as pygopagi.

The Blazek twins (Fig. 3) were broadly united in the pelvic region. Josepha, the right twin, was more robust, had a larger head and face, while Rosa, the left twin, was taller, thinner and with smaller head and face. Josepha had a rudimentary vagina and uterus, while Rosa was normal and had been pregnant.

The Hilton twins (Figures 1 and 2) joined in the same fashion as the Blazeks, were examined by me personally. I was more impressed by their differences than by their similarities. Their associates constantly emphasized temperamental differences. The right twin has the larger head and was an inch and a half taller. Although not as different as were the Blazeks, the Hilton sisters are far more different than all but a few separate monozygotic twins.

The "Siamese twins," Simplicio and Lucio Godena (Frontispiece and Figures 4 and 5) now touring the United States in vaudeville, are natives of the Philippine Islands. According to the photographs published in the newspapers, the twins are distinctly dissimilar. They are united at the base of the spine and stand obliquely back to back. Simplicio, the right-hand twin, is heavier, as were the similarly placed Blazek and Hilton twins. He has a distinctly larger and more brachycephalic skull and a more vertical forehead. Lucio is thinner, and has a dolichocephalic skull with sloping forehead.

A fourth case of pygopagi is illustrated in Figure 6, published by Scammon in his chapter on Fetal Malformations. This case illustrates more strikingly than any of the others how different the two components of conjoined twins may be. This is particularly evident in the heads, that of the right twin being apparently nearly twice as large as that of the left twin. Had these twins lived to grow up, the left twin would probably have been an idiot.

A fifth case of pygopagi is that of the Gibb twins about which I have no information except that furnished by the photograph (Figure 7). Of all the cases studied this shows the greatest difference in facial characters and in expression. In fact the faces are so different that they might belong to entirely unrelated girls.

Personally, I attach considerable significance to the fact that in all four of the cases about which we have information the right twin has the larger head and face. In an earlier study of one-egg twins[2] it was shown that there is a very strong correlation between handedness and head size. In the great majority of separate twins the more right-handed individual has the larger head. Although it seems highly probable, I would not care to state very positively that in separate twins the more right-handed twin, with the larger head and face, must be derived from the right half

THE HILTON TWINS

Figure 1

The joined twins are the only twins that are undoubtedly derived from a single ovum, and they are the least alike of all identical twins! This paradox is explained by the fact that they are the twins which separate latest in development, after the two sides of the embryo had become asymmetrically differentiated. The twins that develop from an earlier separation of the embryonic cell-mass are the most alike, as differentiation is less when separation occurs.

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THE HILTONS DIFFER IN EXPRESSION AND IN HEIGHT

Figure 2

While their facial expression seems quite alike, allowing for differences in the angle of the faces, the twin on the right seems distinctly prettier than the other. The one on the left is 1½ inches taller and somewhat thinner than her sister.

of the original embryo. At least we can assert that the cases of conjoined twins studied so far strongly suggest this conclusion.

The editor of this journal has called attention to a case of Siamese twin calves, which also show marked difference between the two components (Figure 8). The right twin (left in the picture) is better developed in both head and body.

Much more extreme differences between the components of conjoined twins than those described above are exhibited by "autosite and parasite" twins. In these cases one twin component, the autosite, may be nearly normally developed while the other, the parasite, may be quite subnormal in all sorts of ways. The parasite twin, in fact, shows pronounced evidence of inhibited development. Such twins may be thought of as ranking at one extreme of a twinning series, the opposite extreme being the most strikingly similar separate identical twins.

We see, then, that all observers of conjoined twins are more impressed by their differences than by their similarities. In spite of this there survives a conviction that they *should be* identical. The point is made by various writers that conjoined twins are the only twins about whose monozygotic origin we can be sure; hence they should be most similar. Thus Reichle[4] in a recent article on the dermatoglyphics (palm and sole friction ridge patterns) of cosmobia emphatically states with reference to these twins: "There is one group of twins about whose monozygotism there is no reasonable doubt," while the methods of diagnosing separate twins are enveloped in a "fog of uncertainty." Reichle evidently believes that conjoined twins, who are so surely monozygotic, should furnish a norm for diagnosing monozygotic twins in general. He seems to feel that conjoined twins might be expected to show closer resemblances than do separate twins, for they are more closely associated than the latter in every way. When Reichle finds that they do not show at all close resemblance in palm and sole patterns, he loses confidence in the hereditary basis of friction ridges, and concludes that dermatoglyphics are of little value as an aid in the diagnosis of monozygotic twins.

THE BLAZEK TWINS

Figure 3

Rosa at the right (the left component), Josepha at the left (the right component). These twins were born at Prague in 1879. They walked at the age of four and talked in their second year. Their development was normal, and they could speak several languages, and played the violin. As children they romped and played the usual games and could even climb trees. Rosa's son was normal in every respect.

It is the purpose of the present paper to show that Reichle's expectation of close resemblance in dermatoglyphics between components of cosmobia is unjustified, and that the conditions he describes are exactly what are to be expected on the theory of twinning which I advocate.

II. A Theory of Twinning Which Rationalizes Differences Between Conjoined Twins

The theory herewith outlined is the same one I have been advocating for years. Even back in 1912 and 1914 a similar theory was advocated for the nine-banded armadillo twinning situation. According to this theory, we would expect conjoined twins to be less similar than separate twins.

The present form of the theory took its origin from an observation of the incidence of asymmetry reversal (mirror-imaging) in separate identical twins and in conjoined twins. In my studies of fifty pairs of identical twins I found myself disappointed because I found so little mirror imaging in the most strikingly similar pairs. My studies of armadillo quadruplets had led me to expect some mirror-imaging in those twins considered most certainly monozygotic, namely, those most strikingly similar. This expectation, however, failed of realization, for mirror-imaging of the more obvious kinds, such as left-handedness or counter-clockwise hair whorl in one twin of a pair, proved to be almost confined to those twins that are distinctly less similar than are the most strikingly similar sort. The incidence of reversed handedness and hair whorl was plotted in a table listing the fifty pairs of twins in approximately the order of their degrees of general, especially facial, resemblance. Reversals of asymmetry were not found in the most similar twins, were most numerous among the twins of medium-grade resemblance, and less numerous again among the least similar twins, though not absent entirely from the bottom of the list. The reader will find this list in an earlier paper.[2]

The most extensive asymmetry reversals known for twins seem to be confined to conjoined twins, in which many cases of *situs inversus viscerum* have been described for one of the twin components, the other component having the normal situs.

These facts seem to suggest that in human monozygotic twins there is a series of types ranging from the most strikingly similar separate twins at one extreme to conjoined twins, especially the autosite-parasite variety, at the other. The hypothesis advanced to account for this series is as follows:

An essential postulate of the hypothesis is the idea that true monozygotic human twins are the products of the division of a single bilateral embryo into two halves which if not separated, would form the right and left sides of a single individual. If these two primordia become separated, physically or physiologically, each tends to form a whole individual like that which would have appeared had no division occurred. But complete identity of the twin products of such a division is usually prevented by two factors: *a*, there may be a genetic bilateral asymmetry in the original zygote which would prevent the resultant products from the two halves being entirely identical; *b*, there is a progressive differentiation of the two sides of the body toward the mirror-image condition of the two body halves, which can be only partially recovered from by the embryo which has acquired the reversed asymmetry. Hence such an embryo develops into an individual with its asymmetry reversed in many or only a few respects. What variability in the method of twinning can we conceive of as accounting for the graded series, both in degree of resemblance and extent of asymmetry reversal, in twin pairs? I shall attempt to answer this question.

The period of embryonic development during which twinning of the single embryo takes place seems to coincide roughly with the period of gastrulation, though it may occur before or slightly after this period. Thus there is evidence, both from a study of identical twins themselves and from their fetal membranes, that occasionally twinning may occur during the cleavage period prior to the trophoblast and

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STRONGLY BUT FLEXIBLY JOINED

Figure 4

Lucio lifts Simplicio into the air to show how solidly they are attached together. Conjoined twins (cosmobia) are found united in various ways, at the head, at the thorax (Figure 8) and at the sacrum. They may be back to back, side to side, or face to face, but they are always joined so that they are bilaterally symmetrical.

inner-cell-mass stage. There are also evidences in some double monsters that partial separation has taken place subsequent to the completion of gastrulation.

During the period of gastrulation not only is the antero-posterior axis of the embryo determined, but also the bilateral axis or axis of symmetry. But there is no such thing as perfect bilateral symmetry. At best there is developed a more or less pronounced bilateral asymmetry, involving a difference in the expression of paired characters on the two sides of the body, right and left. This bilateral asymmetry becomes progressively fixed during the process of gastrulation.

Therefore, if the separation takes place before gastrulation sets in, the two half embryos would be entirely equipotent and should, unless interfered with by the environment, develop into duplicate individuals showing no mirror-imaging. If, however, the separation occurs very early in gastrulation the two half embryos will not be quite equipotent, but one resultant twin will tend to show slight degrees of asymmetry reversal. There are evidences also that when separation occurs early in gastrulation, before asymmetry has become very firmly fixed, the reversed embryo tends partially or completely to regulate back to the asymmetry of the original embryo. In this way we might account for numerous instances of slight and partial asymmetry reversal and lack of asymmetry (perfect symmetry) between paired organs usually asymmetrical.

If, as seems often to be the case, the separation takes place relatively late in gastrulation, the right and left half-embryos will have had time to have become more or less irreversibly fixed, one in a right- and the other in a left-handed direction. Therefore, after separation, the two twin primordia will not be equipotent. One will tend to express its characters in a right-handed way, the other in a left-handed way. Only one twin will have the asymmetry prospective in the undivided embryo; the other will tend to be inversely asymmetrical in a number of ways, that is, to exhibit mirror-imaging in certain asymmetrical structures. Thus in the majority of twin pairs that fall between the most similar and the least similar we find one twin left-handed or with counterclockwise hair whorl, and these are usually accompanied by reversals in palm patterns.

Again, if twinning comes very late in gastrulation, it may still be possible for division into separate twins to occur, but certain asymmetry fixations may have gone so far that one twin can show only right-handed expressions of certain characters on both sides of the body, and the other twin only left-hand expressions. A study of palmar dermatoglyphics indicates that something of this sort occurs, as will be shown later.

Finally, if twinning comes too late to permit complete separation of the two body halves, double monsters may result, which will show profound asymmetry reversal in the median structures of one component and a tendency for the more or less completely bilaterally paired structures of a component to be the same on both sides; for the right-hand component has been irreversibly fixed as a right-hand primordium and cannot develop a true left-hand condition. Similarly, the left-hand primordium can produce only left-hand expressions of characters. Both sides of the face of the right twin will be like the prospective right side of the face of the single individual; and similarly, both sides of the face of the left twin will be left faces. No wonder, then, that the faces of conjoined twins are usually so different. Doubtless this situation would be found in many other paired parts of the body.

All the facts now in my possession are consistent with this general theory, but there are one or two difficulties that require further examination. For example, it may well be asked why do not *all* asymmetrical characters show in-

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JOINED AND SEPARATE TWINS

Figure 5

The Godena Siamese twins, Simplicio and Lucio, photographed with seven sets of twins of which at least three pairs are evidently identical. This picture emphasizes the fact that conjoined twins are much less alike than are most separate identical twins.

verse symmetry in a twin that shows *some* inverse structures? Again, why do conjoined twins very commonly show *situs inversus viscerum* in the right-hand component, while *situs inversus* is almost never found in separate twins? Let me illustrate the difficulty. Some twins are left-handed but do not show reversed crown whorl, and vice versa; also some twins with reversed palm patterns do not show reversals in handedness or hair whorl. Though the correlation between these various types of reversal is very strong, it is by no means perfect.

The suggestion offered to explain these situations is that the particular type or types of reversal in any individual depends on three factors, (a) the time of the separation, (b) the extent to which the various asymmetries are fixed at different developmental moments, and (c) the extent to which regulation can take place in the reversed embryo back to the asymmetry that was prospective in the undivided embryo. Thus an individual might be able to regulate back to the normal asymmetry in some characters and not in others.

On this theory, asymmetry in the viscera is not fixed until quite late, while that in palm patterns is fixed, or at least biased, rather early. Reversals in hair whorl and handedness appear to belong to about the same time period. In general, the commoner the type of reversal, the earlier is its fixation. Conversely, the rarer the type of reversal, the later is its fixation. Fixation of handedness seems to occur earlier than that of hair whorl, but the former seems more likely than the latter to revert to the normal asymmetry, because more modifiable by training. The existence of so many grades of left-handedness seems to imply degrees of partial reversal, of partial regulation of reversed conditions, or of partial training toward right-handedness.

III. The Theory Applied to an Interpretation of Palmar Dermatoglyphics of Conjoined and Separate Twins

Before presenting the data on conjoined twins a few words of explanation of the nature of bimanual asymmetry in palmar dermatoglyphics seems necessary. In a recent paper[3] it has been shown that there is a rather consistent tendency for the palm patterns in single individuals to be expressed in different ways in the two hands. Left hands tend to have patterns that swing to the ulnar and proximal parts of the palm, while right hands tend to have patterns swinging to the radial and distal parts of the hand. This difference is best expressed in the main-line formulae in which higher numbers indicate more radial terminations and lower numbers more ulnar terminations of main lines. This means that the higher the numbers in the formula the more right-handed is the pattern. Conversely, the lower the numbers, the more left-handed is the pattern. This applies also to the palm patterns proper. In identical twins there is very commonly a reversal of direction of pattern between the two hands in one of the twins when such twin is left-handed or has counterclockwise hair whorl. Hence the direction of asymmetry of the palmar dermatoglyphics tends to be an index of the normal or reversed asymmetry of the appendage in general.

We are, therefore, in a position to decide between almost any pair of palms as to which has the more right-handed and which the more left-handed expression of pattern. For further details as to the dermatoglyphics of twins the reader is referred to the detailed account cited above. The chief point to bear in mind is that relatively right- or left-handed expressions of pattern can be distinguished without much difficulty and that both hands of one twin taken together as a unit may be more right-handed in character than both hands of the other twin.

a. The Palmar Dermatoglyphics of Three Cosmobia (Conjoined Twins)

So far as I have been able to discover, palm-pattern formulae have been published for only three cosmobia, and sole pattern formulae for six. In Wilder's case (1916), the living Siamese twins, Margaret and Mary, were infants at the time of the examination and were too active with their hands to permit satisfactory palm printing. Judging by Wilder's sketch, all four palms show strongly left-handed types of pattern. It seemed easier to get the sole prints and these are described later. The apparent reason for the lack of palm formulae in other cases of cosmobia seems to be that the brachial region was not fully duplicated, and hence there were only two or three hands present.

The best material available for the study of the dermatoglyphics of cosmobia was published by Dr. Reichle in the *Biological Bulletin*.[4,5] In commenting on the cases studied by him, Reichle, seemingly surprised to find such a condition, remarks:

"An examination of the prints and formulae of Table I (containing formulae of five cosmobia) reveals astonishing differences between these indubitably mono-ovular twins. In T. 61 we call attention to the similarity of three hands and dissimilarity of the fourth—the right hand of the right twin."

Let us proceed to analyze the palm prints of the three cases of Reichle in which these prints are recorded:

CASE T. 60 (Duplicitas asymetros. Thoracopagus, Tetrabrachius)

Palm prints:

Right twin
(R.) 10. 7. 6. 3/B. O. O. Ac. L. C 13
(L.) 10. ^{8}7. ^{6}6. 3/B. O. O. Ac. L. C 12

Left twin
(R.) 10. 0. 6. 3/O. O. O. Ac. Z. C 12
(L.) 9. 7. 5. 3/B. O. O. Ac. L. C 12[a]

Without attempting to translate these formulae into the form now advocated by Cummins et al. ('29), it is readily seen that the right twin shows little,

if any bimanual asymmetry. Both hands show moderately right-handed main line formulae. The left twin shows one somewhat reduced right-handed formula on the right hand and a decidedly more left-hand formula on the left hand. Thus we have the condition, seen in many of the less similar separate one-egg twins, of three hands more or less similar and one distinctly different. It appears that there are three right hands and only one left, and that the only left-handed formula occurs on the left hand of the left twin. By way of interpretation it might be suggested that these twins have probably been separated relatively late in the embryonic history after bilateral asymmetry had become rather firmly fixed. Hence the right half embryo has been fixed as a right-hand side so irreversibly that it cannot express a left hand condition in either hand. The left half embryo, however, has retained some plasticity and shows a left pattern on the left hand and a reduced right pattern on the right hand.

CASE T. 61 (Cephalopagus, Synsephalus asymmetros)

Palm prints:

Right twin
(R.) 10. 7. 6. 5/O. O. O. Ac. L. C 13
(L.) 9. X. 5″. 3/O. O. O. Ac. Ac. (C 13)

Left twin
(R.) 9. X. 5. 3/O. O. O. Ac. Ac. C 13
(L.) 9. X. 5. 3/O. O. O. Ac. Ac. C 13

Here the condition differs somewhat from the last in one respect, that there are three left-hand patterns and only one right-hand pattern, namely, that on the right hand of the right twin. Here we must assume that the right half-embryo has retained sufficient plasticity to express some bimanual asymmetry and hence shows a relatively right-hand pattern in the right hand and left-hand pattern in the left. The left twin, however, has become so fixed that it can express no asymmetry, but produces nearly identical left-hand patterns in both hands.

TWINS JOINED AT THE HIPS

Figure 6

Siamese twins joined at the hips are called pygopagi. The differences found in conjoined twins are shown in this picture, the head of the right-hand member being much larger than the other. From Scammon.

CASE T. 144 (Cephalothoracopagus asymmetros)

Palm prints:

Right twin
(R.) 8. 6. 5.′ 3/O. O. O. O. L. C 12
(L.) 8. 6. 5. 3/O. O. O. O. L. C 12

Left twin
(R.) 7. 5′ 5. 3/M. O. O. O. L. C 13
(L.) 7. 5″. 5. 3/O. O. O. O. L. C 12

Here the condition is different from that seen in the two previous cases, but equally remarkable and significant. Both hands of the right twin are nearly identical and have relatively right-hand patterns as compared with those of the left twin. Similarly, both hands of the left twin show extreme left-hand patterns of a nearly identical sort on both hands.

The right hand of the right twin is a little more right-handed in the position of main line *C* than is the left hand. The left hand of the left twin is a little more right-handed in the position of main line B than is the right, a vestige of mirror-imaging. The suggested interpretation is that twinning occurs so late that the right twin is too fixed at the time of separation to express any but right-hand patterns in either hand, only a very slight asymmetry in the expected direction being realized. The left twin similarly has

THE GIBB TWINS

Figure 7

Note the difference in facial expression, characteristic of Siamese twins. They are so different as scarcely to resemble each other as much as ordinary sisters commonly do.

been fixed so as to be unable to express anything but left-hand patterns, but shows a slight asymmetry of the reversed, or mirror-image, sort so common in less similar identical twins.

b. Sole Patterns of Cosmobia

1. In Wilder's typical Siamese twins (Mary and Margaret) three sole patterns are very similar (Margaret's right and left and Mary's left), while Mary's right is very different. Since I have never studied sole patterns, I cannot with any assurance interpret their pedal asymmetry, but if the sole situation corresponds at all with the palm situation, as it doubtless does, the odd pattern of Mary is a strong left-foot pattern though on the right foot, and the other three are equally strong right-foot patterns. Now Margaret, who has two right-foot patterns, is the right twin. The interpretation of this situation would be the same as that offered for Reichle's case T. 60, except that there is pronounced asymmetry reversal in the two feet of Mary, the left twin. As in other cosmobia, Margaret, the right twin was always the larger and heavier twin.

2. *Reichle's Case T.* 16 (Duplicitas symmetros. Dicephalus. Dibrachius, Dipygos) has the following sole formula:

Right twin
(R.) BC—(U+U+U) od.
(L.) BC—(U+U+U) od.
Left twin
(R.) B —U+(U+U) ld.
(L.) BC—(U+U+U) od.

This is a perfect case of three alike and one different and seems to involve three relatively right-foot formulae and one relatively left-foot formula. But here the right foot of the left twin, as in the previous case, shows the left-foot formula, another instance of distinct asymmetry reversal, or mirror-imaging. The interpretation in general would be the same as for the last case.

3. *Reichle's case T.* 61 (palm formulae already given)

Sole prints:
Right twin
(R.) A—(U+U+U) d'meet
(L.) A—(U+U+U) d'meet
Left twin
(R.) W—(U+U+U) d'meet
(L.) A—(U+U)+O d'in

Here the right and left soles of the right twin are the same, showing no pedal asymmetry. Probably both feet have relatively right-foot patterns. The right foot of the left twin is, except in one item, like the two feet of

the right twin and is doubtless more right-footed in pattern than is the odd left foot. Thus we have again three patterns nearly alike and one different. The suggested interpretation is the same as that offered for the last two cases.

4. *Reichle's case T.* 144 (palm formulae already given)

Sole prints:
Right twin
(R.) A—O+ U+U. 2d.
(L.) A- O+ U+U. 2d.
Left twin
(R.) A—O+ (U+U). 1d.
(L.) A—O+ O+U 2d.

Here both feet of the right twin are practically the same, while those of the left twin differ in three details between themselves and in at least two details from either foot of the right twin. On the whole, the left foot of the left twin is more like both feet of the right twin than like his own right foot. Also there is fairly strong mirror imaging, or asymmetry reversal. Again the suggested interpretation is the same as for the last three cases.

5. *Reichle's case T.* 60 (palm formulae already given)

In this case there are only three feet, the left twin having only one foot, the right. Here all three soles are very similar, and, had the other foot been present, we might have had one more case of three alike and one different, the left foot of the left twin being the odd member, as is often the case.

6. *Reichle's case T. 7* (Duplicatas asymetros, Autosite et Parasite. Thoracopagus asymmetros. Epigastrius. Cyclopia).

Sole prints:
Autosite
(R.) A—O+U+O. 1d.
(L.) A—O+(U+U). 1d.
Parasite
(R.) O—O+O+. hy. od.
(L.) AB—(U+U+) 1d.

This represents a case in which no identification has been made of right and left twins. Probably because of secondary distortions this was impossible. All that can be said about this case is that the two feet of the autosite are very similar and show little pedal asymmetry; that the left foot of the parasite is much more similar to both feet of the autosite than to own right foot. It seems reasonable to believe that the autosite is the right twin and has two relatively right-foot patterns, while the parasite has a relatively right-foot pattern on the left foot and a left-foot pattern on the right. This interpretation is in entire agreement with those previously given. If our interpretation of pattern asymmetry in soles be correct, it is remarkable how consistently the right twin shows two right patterns and the left twin shows asymmetry reversal between the two soles.

c. Summary of Data on Cosmobia, and Inferences Drawn Therefrom as to Less Similar Separate Twins

Reichle was obviously somewhat surprised and disappointed to find in Cosmobia, the only indubitable one-egg twins available, so low a degree of correspondence between the twin components with respect to their dermatoglyphics. According to his view, one might expect twins of the conjoined type to be even more similar than separate twins. Their failure to come up to this expectation naturally tended to destroy his confidence in the hereditary character of dermatoglyphics and especially in the value of these characters as an aid to the diagnosis of monozygotic and dizygotic twins. These opinions were formed in the absence of any information as to bimanual asymmetry and asymmetry reversal in dermatoglyphics. Had this information been available he would doubtless have taken a different attitude.

The important advantage of certain cosmobia over separate twins, especially for the problem of bimanual asymmetry in dermatoglyphics, is that we can usually identify the twins with respect to the side of the original embryo from which each has been de-

BOVINE SIAMESE TWINS

Figure 8

Siamese twins joined in the region of the thorax are called thoracopagi. The existence of such twins is another point in the chain of evidence that identical twins do exist in cattle, which has been questioned by some workers. This peculiar specimen is the property of O. B. Coakley, a prominent business man of Collburn, Colorado. For the photograph we are indebted to Dr. C. P. Gillette, Ft. Collins, Colorado.

rived. Thus the two components may be designated right twin and left twin, and there is no question but that they have been derived from the right and left halves, respectively, of the original embryo.

Strikingly enough, in all cases where the palmar dermatoglyphic formulae are given for all four hands, the two hands of the right twin show decidedly more right-handed formulae than the two hands of the left twin. In one case the left twin has one somewhat right-handed pattern on the right hand and a left-handed pattern on the left, but in the other cases both hands of the left twin have considerably more left-handed patterns than either hands of the right twin.

These facts were not know to me when my paper on the palmar dermatoglyphics of twins (Newman, '31) was written, but they are strongly confirmatory of the conclusions reached in that paper. Had the right twin components not shown a more right-hand expression of dermatoglyphics, the principal thesis of that paper would have been badly shaken. As it now stands, however, not only do these data on cosmobia confirm the conclusions based on separate twins, but they also help to explain the rather peculiar dermatoglyphics found in a number of the least similar monozygotic twins. For example, we find in my pair 17 the following palm print formulae:

Twin *A* Right hand
7. 5″. 5′. 3h—t′—A^u/W^s. O. O. O. L.
Left hand
7. 5′. 5′. 3h—t′—A^u/W^s. O. O. O. L.
Twin *B* Right hand
9-7. 9. 5′. 3—t′—A^u/L^c. O. O. L. D.
Left hand
9. 7. 5′. 3h—9′ L /A^c. O. O. M. L/M

Both hands of *B* are decidedly more right-handed in pattern than either hand of *A*. The right hands of both twins are slightly more right-handed in pattern than are their respective lefts. One is tempted to guess that twin *B* was derived from the right half of the original embryo. This guess accords with the fact that *B* has the larger head. Both are right-handed and both have clockwise hair whorl.

Again in my twin pair 14 we have the following formulae:

Twin *A* Right hand
9/7. 9. 5″. 11-5′—t′—A^u/A^c. O. D. L. D.
Left hand
11-7. 9. 7. 5′—t′—A^u/A^r. O. D. I. W.
Twin *B* Right hand
11/7. 9. 7. 11—5′—t′—A^u/A^c O. D. L. D.
Left hand
11-7. 9. 7. 5′—t′—V/A^u. O. D. 1. W.

Both hands of twin *B* show extreme right-hand patterns, the right hand being a little more extreme in main line *D*. In twin *A* the left hand shows a pattern almost identical with the left hand of *B*, while her right hand shows a relatively left-hand pattern. This shows distinct asymmetry reversal in *A*, who also has a counterclockwise hair whorl. Twin *B* has the larger head. One is again tempted to derive *B* from the right half and *A* from the left half of the original embryo.

The formulae of my twin pair 60, the least similar of the 50 pairs diagnosed as monozygotic, are as follows:

Twin *A* Right hand
11 (10). 7. 9 (6). 3—t—A^u. O. O. L. L.
Left hand
7. 5″. 5′ h—?—A^u. O. O. O. L.
Twin *B* Right hand
8. 6. 5″. 5′—t—A^u. O. O. O. L.
Left hand
7. 5″. 5′. 3—t—L^r/A^u. O. O. O. L.

Twin *A* shows a strong right pattern in the right hand and a strong left pattern in the left, while twin *B* shows relatively strong left patterns in both hands, her left hand being the most left-handed of the four hands. *B* is manually somewhat left-handed. It looks as if twin *A* was derived from the right half embryo, and twin *B* from the left half.

Several other formulae of this sort occur among the least similar monozygotic twins, while no comparable situations are found among the most similar twins.

In the light of all this we might modify our rule for adjudging the monozygosity of twins on the basis of their palmar dermatoglyphics to read:

In monozygotic twins one palm of one twin resembles more closely one or both palms of the other twin than it resembles the other palm of the same twin.

This will not include those cases in which both palms of one twin have right-handed, and both palms of the other twin left-handed, patterns. Our list of 50 pairs of twins includes only two pairs classed in this category, pair 33 (28th from the top) and pair 17 (9th from the bottom). Neither of these pairs were ever in quesion as to their monozygosity. This was certain on the basis of their essential identity in all their genetic details. On the basis of dermatoglyphics alone it would have been extremely difficult to arrive at a monozygotic diagnosis of these two pairs. The fact, however, that the types of dissimilarity between the two palms in these two cases are just the same as those exhibited in conjoined twins, would materially assist in such diagnosis.

V. The Bearing of these Studies on the Diagnosis of Monozygotic and Dizygotic Twins

The majority of workers with human twins have had great difficulty in arriving at a clean-cut classification of their cases into monozygotic and dizygotic pairs. It is undoubtedly true that, if the similarity diagnosis is followed out rigidly, unless it be carried to the highest degree of refinement, one group of twins will seem to merge over into the other. It is also true that when statistical comparisons between the two groups of twins are made, the variation curve of one group overlaps rather smoothly on that of the other, suggesting that the whole group belongs to a single graded category. On this account some twin workers are inclined to doubt that there exist two distinct categories of twins.

The data presented in this paper, and the theoretical conclusions derived from these data, tend to explain why we may expect some monozygotic twins to be hardly more similar than some few of the most similar dizygotic twins. Some of the latter, either because they are derived from parents genetically very similar, or because of the chance repetition of much the same genetic complex in two zygotes formed simultaneously, may be as similar in most common features as are a few of the most different monozygotic twins. But the latter will be identifiable as such through a study, especially in connection with dermatoglyphics, of the peculiar workings of the asymmetry mechanism heretofore described. Thus when one has learned to interpret the subtleties of dermatoglyphics, he can use them as an important aid in diagnosing twins. But if used crudely, dermatoglyphics will be only a delusion and a snare.

Finally, it is now my settled conviction that there are two distinct categories of twins and that overlapping of the two groups is only a superficial one that can be resolved by careful study of even the most refractory cases.

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Body and Mind

PHYSIQUE AND INTELLECT, *by* DONALD G. PATERSON. Pp. xxvii+304. $2.50. The Century Co. New York. 1930.

IN science negative results are sometimes more important than positive ones. Superstitions, false beliefs, predjudices, erroneous notions and theories have forever been the bane of mankind as well as of science. Every field of science has at one time or another been retarded by fallacious theories and preconceptions. Chemistry was held back for many years by the phlogiston theory; astronomy was retarded by the geocentric theory; psychology by the body and soul theory; biology by the theory of divine creation, etc., etc. Even today the education of an individual consists more in unlearning than in learning.

Professor Donald Paterson has rendered us a service by definitely disproving the popular and erroneous notion that there is an intimate relationship between physical traits and intellect. He has carefully analyzed the conflicting results of many research workers published during the last forty years and he finds that the prevalent notions regarding the intimacy of the relationship between physical traits and intellect have been greatly exaggerated.

Among the many important questions raised in this book are: Is mental growth dependent upon physical growth? Is the bright child necessarily superior or inferior in physique to the child of average intelligence? Are feeble-minded children and mentally retarded children handicapped by virtue of physical development, physical defects, or poor physical condition? Is size and shape of head an indication of intellect? Does delayed dentition signify mental retardation? Is glandular therapy a panacea for feeble-mindedness? Does body build bear any important relation to intellect or temperament? Are there important mental and personality differences between blonds and brunettes? Can psychological masculinity or femininity be detected through anthropometric measurements of body form? Professor Paterson's answer to these questions is in the negative, at least until better evidence can be adduced to convince us that the opposite is true.

Many of the published studies dealing with the relationship between physical traits and mental traits are based upon incorrect or defective statistical methods. Group comparisons which have been widely used by psychologists can only indicate the existence of probable relationships. Only by direct correlation can the degree of relationship be statistically determined. The positive correlation of two factors is, however, not conclusive proof that they are related as cause and effect. Both factors may be the result of some other unknown factor. Professor Paterson's analysis of some of the published results clearly indicates how easily one can be misled by bad statistics or by a misuse of them.

Ever since Adam's time human beings have been labelling and classifying everything about them, including their fellow human beings. The classification of extravert and intravert, Kretschmer's pyknic, athletic and asthenic, the normal and abnormal, the moron and genius are worse than useless as far as exact scientific terminology is concerned. According to Paterson the work of investigators "since 1914 has everywhere tended to yield results confirming the theory of one type, that of mediocrity."

The author admits that "there is a growing mass of evidence that the most potent factor responsible for the range of individual differences in intellect is biological heredity." As far as the physical measurements of school children is related to their intelligence he informs educators that they are useful "in determining the size of desks and seats to be installed in the school room!" And the book concludes approvingly with this quotation from

(*Concluded on page* 230)

EDUCATION AND EUGENICS

PAUL POPENOE*

THE study of heredity has emphasized the individuality of the child, and this emphasis has affected the educational system perhaps as much as one could expect, in view of the size, inertia, and crystallization of that system. A careful study of the subject is yet lacking. The whole question of the relation between genetics and education has recently been examined by a group of German authors,[5] but the results are rather disappointing. The important implications of a study of heredity justify a good deal more application than these authors have made.

The Mentally Inferior

Possibly the first important change that occurred in the educational system, as a result of insistence on the differences among children, was the recognition of a large group of more or less uneducable ones at the bottom of the scale. If an arbitrary line be drawn at 70 IQ, those below it probably make up 5% of the whole school population.[7] The recognition that the percentage is so high is gaining ground slowly, but it will receive a strong impetus from the White House Conference. Says the report[11] of this conservative body:

"For want of a better word, the terms 'mentally deficient' and 'mental deficiency' are used throughout this report in a generic sense to denote that 15% (approximately) of the total population the United States whose level of intelligence does not or in all probability will not exceed a mental age of 12 years. Using this criterion, it is estimated that approximately 13% of the total population are intellectually subnormal or retarded but may nevertheless be socially adequate; similar estimates assign about 2% to the definitely feebleminded class lacking the ability to manage and support themselves or to become socially self-directing'"

Educationally, the 13% are much more important than the 2%. They clog up the grades, hold back the normal pupils, and lower standards throughout. In progressive cities, many of them are segregated in special classes or schools where they can be given educational opportunities (at extra expense) suited to their capacities. One of the greatest needs is to follow these children up after they leave school. What becomes of them? There are few studies that throw any light on this question. Probably half of them become self-supporting and merge with the bulk of the population.[9] Probably many of the other half drift into the ranks of the delinquents and dependents. Supervision during the first few years after they leave school would probably pay for itself in preventing the delinquency of some of these misfits, in making possible the sterilization of others, and in furnishing information on which guidance might be wisely based. This is one of the points at which the educational system might make a real contribution to eugenics.

The Superior

At the other extreme are the superior pupils. The most careful study of these is that carried out for some years by L. M. Terman and his associates of Stanford University. The latest report[10] on this group (representing approximately the brightest child in each 1000 in the California schools) has just been published. Seven years after the original study, the gifted children are found to maintain their superiority both educationally and socially, and in most cases to be headed toward useful careers.

There is an interesting development, however. Whereas the boys stand just

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where they did seven years ago, on the average, the girls show an average falling off in intellect, amounting to 17 points on the IQ scale. Apparently adolescence is not favorable to the maintenance of the most highly organized intellectual processes in girls, because of the strain of differentiation.[8] "Boys not only become increasingly more likely than girls to have a high IQ as they advance in age, but they are more likely than girls to retain a high IQ earlier evidenced," is the conclusion of the Stanford study.

Such a conclusion affects only a small fraction of the whole population; it does not seem to hold true for the bulk of the two sexes. But it points toward one explanation for the rarity of female genius, and suggests some inferences regarding the higher education of the two sexes, that need not be expanded here.

There are other differences in development,—more individual than sexual,—which are of the greatest importance to educators. These are brought out in detail in the work which Günther Just has edited.[5] In body, in intellect, in emotion, children do not progress evenly, and the attempt to treat them in the mass, without regard to these differences, is an almost inevitable but an extremely serious defect of modern education.

Coeducation and Eugenics

A great deal more work is needed to develop an accurate body of knowledge about the differences between the sexes. This involves the whole problem of coeducation. If the sexes were as different as is sometimes alleged, it might be taken as an argument against coeducation. But there are some important factors that tend in the opposite direction.

Sexual differentiation is apparently favored by coeducation, for K. B. Davis found[2] the amount of homosexuality among graduates of women's separate colleges greater than among the alumnae of coeducational institutions. The basis for this abnormality still remains one of the most obscure problems in human biology. One turns hopefully to Richard Goldschmidt's new book on sex intermediates,[3] only to find that he too throws up his hands. The only contribution he makes is to disavow a theory he previously held that homosexuality in men is comparable to some of the genetic sex intergrades in gipsy moths. Evidence tends more and more to suggest that it is in most cases due to faulty education, and that coeducation is one of the best correctives. The social advantages of coeducation should be kept, even if the curriculum for the two sexes is somewhat more differentiated than is at present the custom.

Another most important aspect of coeducation is its contribution to sexual selection. Data collected during the last five years by my students at the summer sessions of Teachers College indicate that so far as the educated part of the population is concerned, the best chance one has of finding a suitable mate is to meet one in a coeducational college; and this is borne out by Mrs. Chase Going Woodhouse's interesting study of successful marriages.[12] All of the indications are that this function of coeducation is increasing in importance from year to year, perhaps because other facilities for meeting potential mates are becoming rarer and rarer. Parenthetically, it has been alleged that the great increase in attendance of adult extension courses (night schools) in large cities during the last decade has been largely due to the hope on the part of the attendants that they might in this way make acquaintances which would offer possibilities of marriage. This is virtually denied to many in large cities now because of the almost complete lack of any recreational forms of social life that promote acquaintances between like-minded persons of opposite sexes. Marriages in such groups would be expected to turn out well, because of the similarity of background and tastes that seems to be the most important factor in conjugal happiness. A recent maga-

zine writer[4] who claims that when husband and wife first met in a co-educational college, only one marriage in 75 goes on the rocks, has but scanty data to support her conclusion, but it is probably not far from correct.

Scholarship Loans and Marriage Prospects

A hindrance to this desirable process is the custom of providing scholarship loans for deserving students. The result is to leave the individual at graduation not only facing the necessity of getting established in the world and making a living, but of paying off a college debt before he can think of marriage. Handicap enough to a man, such a load may be almost fatal to a woman's matrimonial chances. If a desirable mate offers himself, she can not well say, "I should be most happy to marry you, provided you will assume my floating indebtedness." Perforce she concentrates all her attention on her job, to free herself from debts before considering marriage; and the delay is too often fatal to matrimonial hopes, since the college girl appears to have but a narrow margin, anyway, that separates her from lifelong celibacy. Scholarship aids to superior students should be in the form of outright gifts, and the present loan funds should be gradually converted or abolished in the interests of eugenics,—not to say humanity. An alternative would be to announce that the obligation would be cancelled on marriage.

Such considerations do not fall within the scope of Dr. Just's book, but they receive ample attention from Fritz Lenz in the latest revision of his well-known work.[1] This volume will be welcome to all who are following the progress of eugenics in the civilized world.

Ideally, the educational system must be thought of not merely as a forcing machine for stuffing a certain quantity of facts into the youthful mind, but as a series of sieves through which the whole juvenile population may be passed, the various levels of capacity in different directions being separated out and each one given its appropriate opportunity. Fundamental to the whole process must be an education of all but the most inferior for marriage and family life.

Selection of Teachers

Rapid strides are being made in this direction,—more rapid than anyone could have hoped, even a decade ago. The principal limiting factor is now the lack of teachers with suitable experience and personality.

All signs point to a serious oversupply of teachers within the next decade. The training schools annually turn out larger crops of young women armed with the state certificate, while the falling birth-rate insures a steady decline in the number of children to be taught,—or at least, in the rate of increase of the school population. Competition for teaching jobs will therefore become intense.

Attention of eugenists should be directed toward taking advantage of this fact, by making selection depend on suitable personality and, where possible, on successful family experience.

Opposed to this, the natural tendency will be to make selection depend on longer and longer academic preparation. California now requires four years' preparation of its teachers, but probably will soon require five. This is likely to be a step backward, eugenically, promoting the existence of a teaching caste made up of professional celibates without satisfactory social outlook. It would be far more worth while to take advantage of the pressure to eliminate some of those with psychoneurotic tendencies, those from unhappy family backgrounds or with conflicts that they are likely to pass on to their pupils; and when other qualifications are equal, to give preference to those who have married happily and brought up children of their own successfully. In this way the child's attitudes would be insensibly directed toward family life.

Marriage Counsel Bureaus

No matter how well the schools might function in this respect, there would still be a need for some post-graduate facilities, so to speak, to provide individual instruction and assist in solving personal problems involving marriage and parenthood. There is now but one such institution on a broad scale in the United States, namely, the Institute of Family Relations, in Los Angeles.

In Europe, however, there are more than 200 clinics or marriage counsel bureaus, most of them officially conducted at the expense of the taxpayers, and representing one of the most striking lines of social progress of the last decade.

To the literature on this movement is now added an extensive work[6] by two German authorities, one of them (Dr. Muckermann) being perhaps the foremost eugenist in the world from the Roman Catholic group. Dr. Muckermann's plea is for a eugenic orientation of these bureaus. They must serve not merely individual needs and interests, but the welfare of society and the progress of the race. They should be staffed only by qualified eugenists, and every decision must be made on eugenic grounds.

No one could sympathize with this ideal more than I; but my own experience leads me to believe that it is pedagogically not sound. Few normal persons,—in this generation, at least,—will consult a marriage counsel bureau to be told whether or not they should marry such and such a person. When doubts are expressed, my experience, like that of Roswell H. Johnson and others with whom I have talked, is that the doubts are nearly always unnecessary. In other words, those who are uncertain as to the eugenic fitness of a marriage, once it is seriously contemplated, are those whose eugenic consciences are unduly sensitive. Those who ought to question their own marriages have not enough sense, or enough feeling of responsibility, to do so.

The marriage counsel bureau, then, must devote itself largely to providing young people, once they have planned to marry, with the help necessary to make this marriage a success. The task of providing them with the proper attitudes and standards of wise choice must be done long before,—mostly in the grammar schools. Here is another responsibility for the educational system. Its successful discharge depends not on adding new courses to the curriculum, but on a proper orientation of the courses already there. This depends, in turn, on proper personnel in the faculty or teaching body. Insistence on a eugenic selection of teachers is therefore an imperative necessity in the United States at the present time.

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DOES X-RAY TREATMENT PRODUCE A GENETIC AFTEREFFECT?

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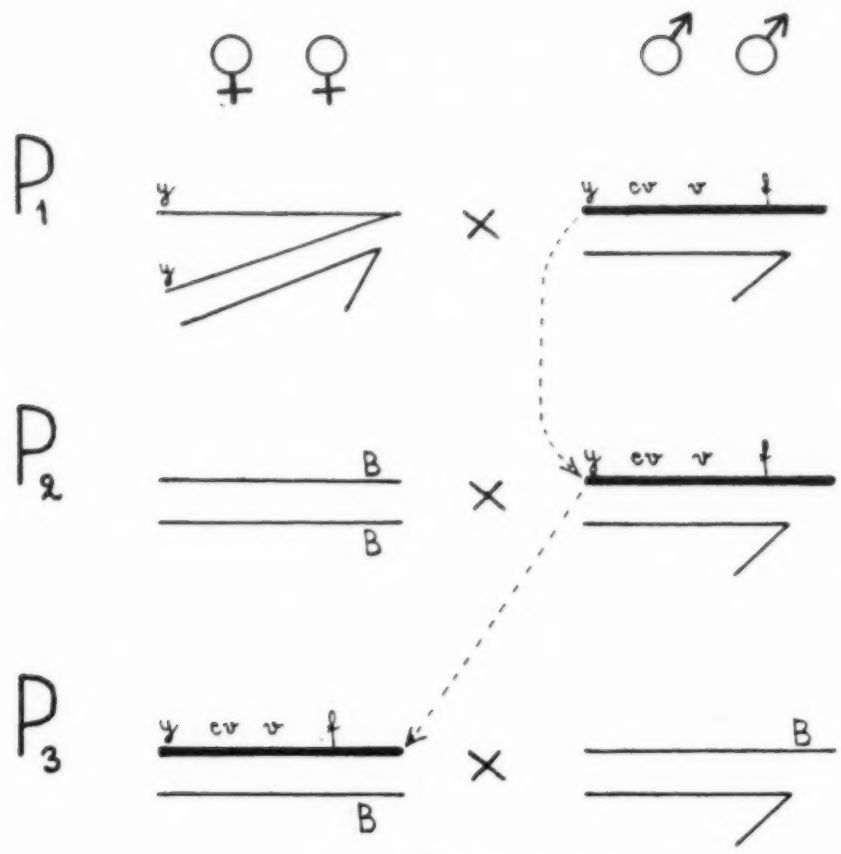
THE whole complex of problems, arising in connection with Muller's discovery of the genetic effects of X-rays is, in a brilliant manner, formulated and partly already proved experimentally by Muller himself and by other geneticists, who are working in this direction.[1, 2, 4, 5, 7, 8, 9]

This complex of problems can be divided, somewhat artificially indeed, into two groups: 1. *"purely genetical problems,"* such as: quantitative studies of the mutability of a species and of the different changes of an individual gene, genetic and cytological studies of the chromosome-aberrations, produced by treatment, etc.; and 2. *"physical problems,"* concerning the nature of the effect of treatment and the intimate nature of the process of geno-variation. The data, presented by the works of Muller and of other authors, indicate, that the effect of X-ray treatment is probably due to intramolecular reconstructions, caused by the direct influence of electrons or individual Röntgenquants upon individual genes The excellent work of Hanson and Heys,[2] as well as our own unpublished data, tends to show that probably the free electrons have the main importance in causing genic changes. But *a priori* it must be admitted as a possibility, that at least a part of the genetic effect of X-ray treatment may be of secondary nature and be due to some chemical or other changes, primarily induced by X-ray treatment. In this case we could expect an after-effect. Such a possibility is especially supported by the work of Woskressensky,[10] who has recently reported the results of his experiments, which tend to show that X-ray treatment accelerates the development of *Drosophila melanogaster* and, that this acceleration persists throughout the next generations and is gradually extinguished towards the tenth generation (abstract of a paper read before the *Allrussian Genetic Congress,* 10-16 January, 1929). The author interprets his results as an after-effect of X-ray treatment, of the type "enduring modifications."

Hence, it is of interest to determine experimentally, whether the X-ray treatment has any after-effect (in the next generations) upon the process of geno-variability. In the course of our X-ray experiments, many crossings were made, which enabled us to detect the treated X-chromosomes in later generations. In arranging crossings, where the female contains a previously X-rayed chromosome, which passed through a male (and so showed, that it does not contain a lethal, directly induced by treatment), we can compare the numbers of lethals, which arise in the X-chromosomes directly under treatment and in the next generations. The schemes of such crossings are given in Figures 9 and 10.

Similar experiments of Muller, started in order to test the "compound gene hypothesis"[4] (tables 7 and 8), have not decided the question of the existence of an "after-effect," since the P_3 and P_4 cultures gave a somewhat high, but statistically not quite significant rate of lethals. Hence, further data must be furnished in order to prove this point.

In the type of crossings, shown in Figure 9, the X-rayed males (in this case containing the genes *yellow, cross-veinless, vermilion* and *forked* in their X-chromosomes) were crossed with *yy* (*"attached XX," homozygous yellow*)



CROSSINGS TO TEST "AFTEREFFECT" OF X-RAYS

Figure 9

Scheme of crossing, made in order to test the "after-effect" of X-ray treatment upon the mutability in the X-chromosomes of Drosophila melanogaster. The P_1-♀♀ are of the "attached-X" type. (The solid lines represent the treated X-chromosomes.)

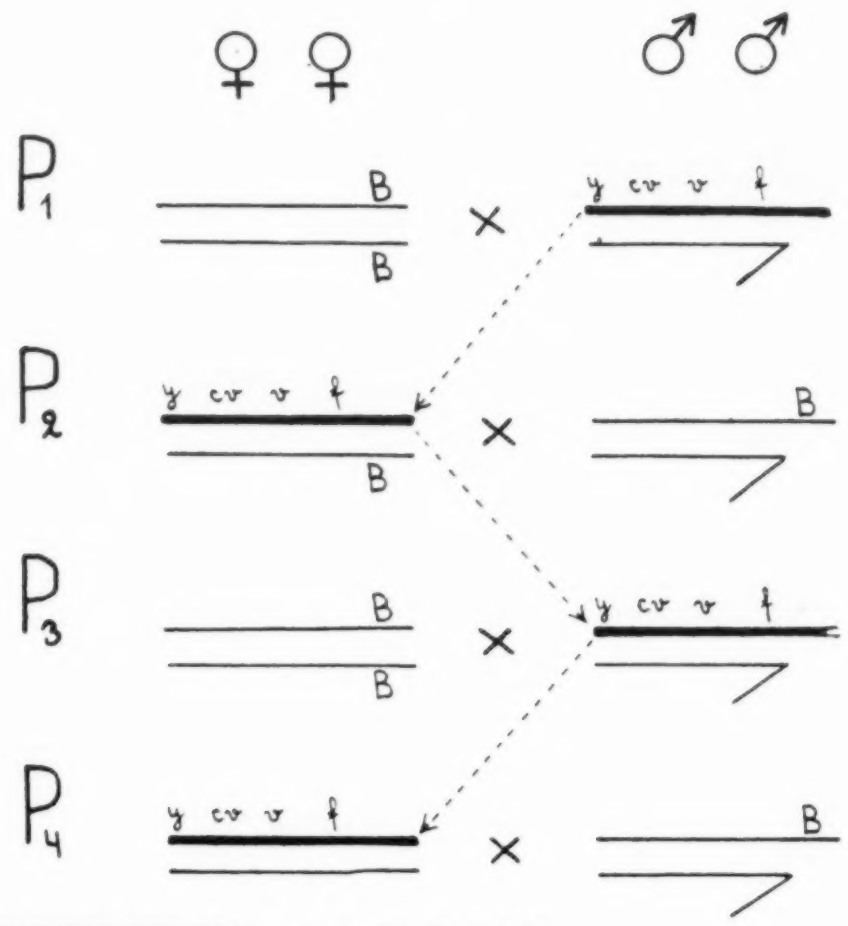


Figure 10

Scheme of crossings, made in order to test the "direct effect" (P_2) and the "after effect" (P_4) of X-ray treatment upon the mutability in the X-chromosomes (the solid lines represent the treated X-chromosomes). The P_1 males were X-rayed.

females; the F_1-males from such matings receive their X-chromosomes from the father and, since they are alive, they do not contain sex-linked lethals. These males are then mated with *Bar* (or *ClB*) females and the F_2-females from these matings can be used in order to test the lethals, arising now in the previously treated X-chromosomes (P^3 of Figure 9).

The crossings of Figure 10 represent a simple case of criss-cross inheritance. X-rayed males are crossed with *Bar*-females (P_1) and the heterozygous F_1-females are then crossed with their *Bar* brothers (P_2). Those *y cv v f* (treated) chromosomes of the P_2-females, which do not undergo crossing-over and are lethal-free, will give in F_2 *y cv v f* males (P_3-males), containing the previously treated X-chromosome; these males can be crossed, like P_1, with *Bar* females (not from the X-rayed cultures, because a part of the F_2 *Bar* females can receive through crossing-over a lethal from the X-rayed chromosome) and the daughters of these matings (P_4 ♀ ♀) can be tested, in order to see, if new lethals arose in the previously treated X-chromosomes (P_4).

756 crossings of the types P_3 from Figure 9 and P_4 from Figure 10 were examined. The treated X-chromosomes were not always of the *y cv v f*—constitution, as shown on the diagrams; in some cases *X-ple* (*sc ec ct*^{6} *v g*^{2} *f*) or *w m B* chromosomes were used. But in all cases (*y cv v f; X-ple; w m B*) the treated X-chromosomes contained signal-genes throughout the whole length, so that all the crossovers could be detected. For comparison 672 crossings with directly treated X-chromosomes (type P_2 of Figure 10) and 793 untreated control-matings were also examined. The X-ray dosage, used in these experiments, was as follows: 50 kV, 5 mA., a target-distance of 15 cm., 1 mm. aluminum filter, length of treatment 45 (or in some cases 60) minutes.

The results of these experiments are shown in Table I. In 49 out of 672 chromosomes, lethals arose directly under treatment (all the 49 lethals—

in the treated X-chromosomes); besides this, 4 visible genovariations appeared, which also arose in the treated X-chromosomes (*white, miniature, cut?* and a reversion from *forked* to normal). The 756 crossings with previously treated X-chromosomes showed 2 lethals (one of them in a previously X-rayed X-chromosome) and, besides this, a semi-lethal, which killed only a part of the males and probably prevented crossing-over throughout the whole X-chromosome. The culture of this semi-lethal was lost, before the exact analysis was completed; this factor appeared in one of the crossings of the type P_3 from Figure 10 and probably arose directly under treatment (in the P_1 male). The 793 untreated control-crossings contained one lethal-factor.

The results of our experiments surely tend to *deny* the existence of a pronounced "after-effect" of X-ray treatment upon the rate of mutability. Two lethals out of 756 tested chromosomes is, certainly, a somewhat high ratio for "normal" conditions, but the rate of mutability, as *Muller* has shown,[3, 6] is so variable, that this result can be ascribed to chance. The question, whether a slight "after-effect" of X-ray treatment upon the rate of mutability is actually present, can be decided only by analysis of very extensive material.

Summary

672 crossings, tested for the *"direct effect"* of X-ray treatment upon the rate of mutability (type P_2 of Figure 10), gave 49 lethals and 4 visible genevariations. Among 756 crossings, tested for the "after-effect" of treatment types P_3 of Figure 9 and P_4 of Figure 10), only two contained lethals and none visible genovariations. The 793 untreated control matings contained 1 lethal (Table 1). The existence of an "after-effect" upon the rate of mutability, at least of any pronounced effect, is rendered very doubtful by this test.

TABLE I.—Crosses to Test the Genetic "After-effect" of X-Rays.

Kind of cultures	Number of fertile cultures	Number of lethals	Number of visible genovariations
Cultures tested for the "direct effect" of X-rays	672	49	4
Cultures tested for the "after effect" of X-rays	756	2 - 1	
Untreated controls	793	1	

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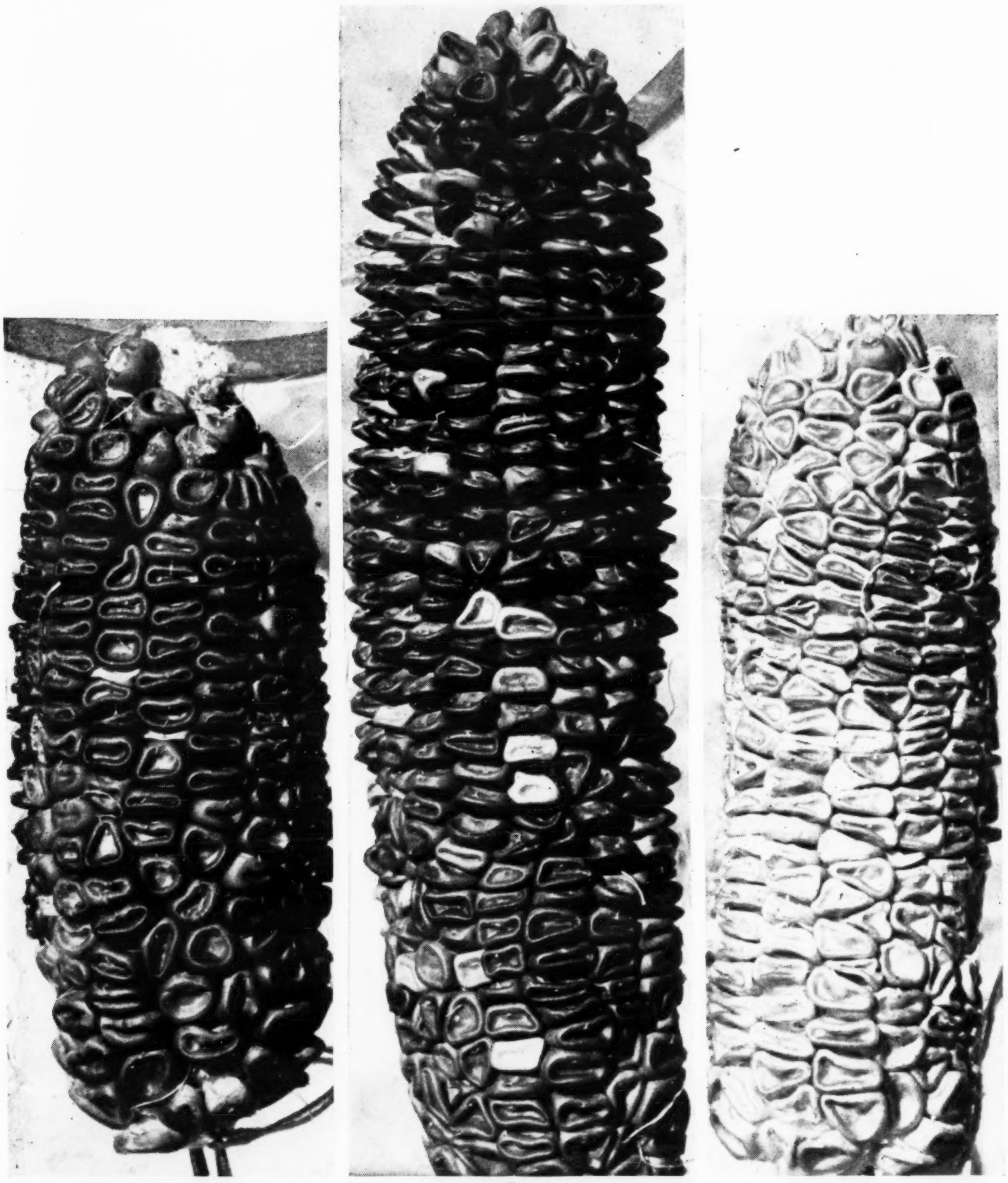

A B C

PURPLE AND DILUTE PURPLE ALEURONE COLOR

Figure 11

Three ears belonging to pedigree 9327: *A* is homozygous for shrunken endosperm and normal purple aleurone, *B* is homozygous for shrunken endosperm but segregates normal purple and dilute purple aleurone in the relation of 3:1, and *C* is homozygous for shrunken endosperm and dilute purple aleurone. Photograph by the author.

HERITABLE CHARACTERS OF MAIZE

XLI—Dilute Aleurone*

WILLIAM H. EYSTER†
Bucknell University

KERNELS of maize having a very much diluted aleurone color were first observed as segregates on ears which were homozygous for purple aleurone and shrunken endosperm, and were being studied in connection with studies concerned with the aurea chlorophyll deficiency. Kernels having dilute aleurone are pale purplish-yellow or pale purplish-white in color depending upon whether the underlying endosperm is yellow or white, and are easily distinguishable from the deep purple kernels on the same ears.

That the dilute aleurone color is controlled by a genetic factor was strongly suggested by the ears of plants grown in my cultures under pedigree 9327 which includes (1) ears with all kernels deep purple in color, (2) ears with normal purple and dilute purple kernels in ratios approximating 3:1, and (3) ears with all kernels dilute purple in color. These three types of ears occurred in the ratio of 1:2:1 and are illustrated in Figure 11. The complete data from these are not available at present. Ear 9327-3 (X), however, contained 258 normal purple and 84 dilute purple kernels. This is a ratio of 3.05:1 and may be considered as conclusive evidence that the dilute aleurone color is produced by a genetic factor. As a symbol for the dilute aleurone gene, *da* has been used in my experiments.

The purple and dilute-purple kernels from ear 9327-3 (X) were planted separately in the experimental field and grown during the summer of 1930. The purple kernels gave rise to 75 green and 5 aurea plants, while the dilute-purple kernels produced 4 green and 27 aurea plants. These results can be explained satisfactorily by assuming a linkage between aurea and dilute aleruone with approximately 11.5 per cent crossing over, as indicated in the comparison below‡ The deviations between the observed frequencies and those expected for independently inherited characters are very wide, while the expected frequencies when linkage with 11.5 per cent crossing over is assumed agree very closely with the observed frequencies. Back-crosses have been made and material is at hand for determining more accurately the map distance between the *au* and *da* genes.

Data have been published which show that aurea is the expression of a gene which has its locus in Chromosome I between the loci of the genes for polkadot leaves and argentia. The data which are available at the moment do not let it be known on which side of *au* the *da* gene has its locus. Crosses have been made which will make it possible to determine the exact position of *da* in Chromosome I.

*Paper number 2. Contributions from the Botanical Laboratory of Bucknell University.

†EYSTER, WILLIAM H. Five new genes in chromosome I. *Zeitschrift für induktive Abstammungs und Vererbungslehre* 49:107-130.

	Da Au	*Da au*	*da Au*	*da au*
‡Observed frequencies	75	5	4	27
Expected frequencies with no linkage	62	21	21	7
Expected frequencies assuming linkage with 11.5 per cent crossing over	77	6	6	21

Nicotine Percentage in Tobacco Breeding

THE vogue of nicotine-free and nicotine-deficient tobacco is a curious phenomenon. Unquestionably tobacco is smoked *because* of the nicotine it contains. The habit having been established, and health consideration demanding less nicotine, very satisfactory results seem to be obtained by smokers who get the smoke without the drug. Cases have been observed in which smokers obtained marked relief by using "nicotine-free" tobacco that analysis showed actually to contain a higher percentage of nicotine than the ordinary cigarettes they had been using.

Thus while there may be some doubt as to which effects of nicotine (or the lack of it) on the user are psychological and which physiological, the natural distribution of nicotine in tobacco is of some interest genetically. Dr. Paul Koenig, director of the Tobak-Forschungs Institute fur das Deutche Reich, gives in *Forschungen und Forstschitte* (Berlin 1930) a summary of the history of our knowledge of nicotine and discusses the rôle of the drug in the life of the tobacco plant.

Pure nicotine was first discovered by Reimann and Possett in 1828. It was synthesized by Melsens in 1843. Then followed the evolution of various methods of quantitative analyses. In 1930 Dr. W. Petri, of Coblenz, published an account of a method for removal of nicotine which disclosed that of the 300 commercial products claimed to be free, or to contain only a low percentage of the alkaloid, only one was genuine. This proof of the inefficiency of the method of removal makes clear the importance of breeding pure strains of tobacco which have been found to contain a low percentage of the drug.

Cultivation, fertilizing and breeding were found to affect the nicotine content of the plants. It was found that pure strains, even although grown under differing conditions and showing when growing varying percentages of nicotine, in the dried condition yielded exactly the same amount of nicotine. It will therefore be possible in the future to produce pure strains of desired strength, which keep the natural taste and aroma which is lost in the extraction of nicotine by chemical means. Conversely, it will be possible by selection to develop strains richer in nicotine than existing varieties. These will be especially valuable in the production of the drug for insecticide purposes.

"Free Will" and Determinism

THE FALLACIES OF FATALISM, *by* CHAS E. HOOPER. (The Real World and the Rational Will.) Pp. XI+211. Watts & Co., London. 1930.

THIS book is "a challenge to Determinism from a critical-realistic point of view," which challenge is founded on a "re-examination" of knowledge relating to the physical world, to the human mind and to society. The general trend throughout resolves itself into a systematic attack upon the pet ideas of the deterministS, from a philosophic standpoint, from which the concepts and "laws" of physics, biology, psychology and sociology are reviewed and discussed in modified teleologic terms.

The presentation is divided into two parts, the first being concerned with the varieties, powers and interactions of physical entities or concrete things, and the second with comparative values in relation to such human attributes as

culture, mind, personality, conduct and rational will. Character is defined as "the totality of a person's affective and conative dispositions, together with the degree in which these are regulated (controlled or cultivated) by foresight, by conscience, or by rational will." Foresight may be combined with either conscience or rational will, but it also foresees the means toward any imagined end, and anticipates events which do not depend on our will. Conscience is defined as "that which represents the force of customary morality" and rational will is "that which seeks conformity to human nature at its best," which phrase may mean *"the will to combine the free and full development of one's own personality with the self-imposed law of maintaining right relations with fellow human beings and groups."*

Purposes which are correlative to objectives are considered to be among the fundamental elements in personality expressions, along with some unconscious, suppressed conative tendencies. Personal character also contains a fund of mental indolence, fatigue elements and dreamy directionless thought processes. Purposes in life and precepts to live dutifully issue from the rational will.

The author shows some concern over the use of the word "law" in science, for instance, "It is an unfortunate anomaly in scientific language that the word *'law'* should have been selected to mean what is believed to be an invariable sequence, when its original reference is to a rule humanly needed *precisely because it is liable to be disobeyed.* I believe that this ambiguity of the word tends powerfully to a confusion between the categories of fact and value as well as to a denial of the reality of freedom which deprives good conduct of any essential merit, while absolves wickedness from any serious blame."

In matters of crime the Free-volitionist makes allowance for hereditary and environmental defects in the criminal constitution, but refuses to believe that a non-psychotic criminal is produced wholly without fault of his own; and thus does not concur with the modern scientific deterministic theory of crime. Moreover, the standpoints of the evolutionist, with his pre-human ancestry determinants and of the theological Determinist with his ideas of original sin, are found to be unreasonable.

Those interested in such arguments will find food for thought in this book which compactly presents material from many sources. There is an extensive and helpful glossary appended, defining the important terms in the sense in which they are used in the text; an example, which could be followed with profit by all authors presenting actively controversial subjects, where an exact understanding of one's position is desired.

N. D. C. LEWIS.

Books Received

BOOKS are acknowledged in this column as received, and such acknowledgment must be regarded as sufficient return for the courtesy of the sender. As far as space permits, books that contain material of special interest to the readers of the JOURNAL *will be reviewed in later numbers.*

PLANT PHYSIOLOGY, with Reference to the Green Plant, *by* EDWIN C. MILLER, PH. D., Professor of Plant Physiology, Kansas State Agricultural College. Pp. 900. 14 Chapters. New York and London, McGraw-Hill Book Company, Inc. 1931.

Sap pressures, chlorophyll, etc., but even under reproduction hardly a chromosome.

HUMAN HEREDITY, *by* ERWIN BAUR,

EUGEN FISCHER, and FRITZ LENZ. Translated from the German by Eden & Cedar Paul. Pp. 734. 5 Sections, 15 Chapters. 172 Illustrations, 9 Plates. Price $8.00. New York, The Macmillan Company. 1931.

A German work, that has been standard for a number of years makes its bow to the English-speaking world.

LIKE BREEDS LIKE, A Non-Technical Treatise Covering Heredity, Live Stock Breeding and Eugenics, *by* HARRY H. COOK. Pp. 383. 57 Chapters. 77 Illustrations, 21 Tables. Price, $3.50. Research Department, Sans Aloi's Jersey Farm, Ontario, California. 1931.

A confession of faith in heredity by one who speaks with the authority of twenty years' successful practice of breeding, evidenced by records made and medals won.

NUT GROWING, *by* ROBERT T. MORRIS, M. D. Revised Edition. Pp. 236. 3 Parts, 12 Chapters. Price $2.50. New York, Macmillan Co. 1931.

Dr. Morris brings developments in his pet hobby up to date.

EDUCATION, CRIME, AND SOCIAL PROGRESS, *by* WILLIAM C. BAGLEY. Pp. 150. 8 Chapters. Price $1.20. New York, The Macmillan Co. 1931.

Something wrong in the schools—even though Dr. Bagley tends to be environmentally conditioned the book has excellent points.

A TEXTBOOK OF EXPERIMENTAL CYTOLOGY, *by* JAMES GRAY, M. S., F. R. S., Fellow of King's College, Cambridge, and Lecturer in Experimental Zoology, University of Cambridge. Pp. 516. 18 Chapters, 3 Plates, 205 Figures, 75 Tables. Price, $7.50. New York, The Macmillan Co. 1931.

Physics, chemistry and microscope applied to the Unit of Life.

THE MAKING OF MAN, An Outline of Anthropology, *Edited by* V. F. CALVERTON. Pp. 879. 6 Parts, 39 Chapters. Price, 95c. New York, The Modern Library.

Quite a ways from the sticks, and snails and puppy-dogs' tails of Mother Goose.

STUDIEN ZUR FERTILITAT, *by* PROF. DR. G. L. MOENCH, head physician, gynecological service, New York Post Graduate Medical School and Hospital. Pp. 143. 24 Illustrations and 14 Tables. Price 12 RM. Stuttgart, Ferdinand Enke Verlag. 1931.

Somewhere between ten and twenty per cent of marriages are involuntarily without issue—New light on whys and wherefores.

MAIZE IN SOUTH AFRICA, *by* A. R. SAUNDERS, Senior Research Officer, Department of Agriculture, Union of South Africa. Pp. 284. 13 Chapters. 72 Illustrations. Price, £1 net. Johannesburg, Central News Agency Limited. 1930.

Zea far from home—but apparently very much at home.

WHAT IS LIFE, *by* AUGUSTA GASKELL. Pp. 324. 3 Parts, 9 Chapters. Springfield, Ohio. Charles C. Thomas. 1928.

A double-barreled introduction by Pearl and Compton (K. T.) leads us to suspect that Mrs. Gaskell has guessed it, and it's only [hypothetical and just a little mystical?] *Z*-bodies after all.

ORDER OF BIRTH, PARENT-AGE, AND INTELLIGENCE, *by* L. L. THURSTONE and RICHARD L. JENKINS. Pp. 135. 3 Parts, 31 Chapters. Price $3.00. Chicago, The University of Chicago Press. 1931.

When the probable errors are cleared away there doesn't seem to be much correlation of the above, but a number of other interesting correlations are noted and discussed.

SOME RECENT RESEARCHES IN THE THEORY OF STATISTICS AND ACTUARIAL SCIENCE, *by* J. F. STEFFENSEN. Pp. 52. 3 Lectures. Price, $2.00. Cambridge, England, The University Press, and New York, The Macmillan Co. 1930.

Very, very complicated.

CAN SCIENCE EXPLAIN LIFE? *by* CARL F. KRAFFT. Pp. 94. Price $1.00. Lancaster, Pa., The Science Press Printing Co. 1931.

Another attempt to get to the bottom of this life business. No *Z*-bodies—just spirazine triplets, and an introduction by the author.

HEREDITY, *by* A. FRANKLIN SHULL, Professor of Zoology in the University of Michigan. econd Edition. Pp. 345. 28 Chapters. 143 Illustrations and Charts. Price, $3.00. New York, McGraw-Hill Co. 1931.

A standard work on an important matter goes into a second edition.

SEXTUPLET LAMBS

An Example of Exceptional Fertility in Sheep

J. F. Wilson and D. W. Gregory
University of California, Davis, California

Photo by Kromer

EXTREME FECUNDITY IN SHEEP

Figure 12

This "litter" of six living lambs is apparently a record.

ON March 18, 1931, near Woodland, California, a purebred Romney ewe (registry No. 3866, A.R.B. record) gave birth to the six living lambs pictured above. The ewe is the property of Dr. E. E. Brownell of San Francisco.

One of the lambs, that shown on the extreme left in the photograph, died of pneumonia the day following birth. It was the "peewee" of, shall we say, the litter. The other five were living and thriving on April 3 when these paragraphs were written.

Previous lambing records offer no explanation for the extreme prolificacy of this ewe. They are as follows:

Year	*Date Lambed*	*No. of Lambs*
1928	April 24	1, ♀
1929	Mar. 19	2, ♂ and ♀
1930	Feb. 21	1, ♀

The ewe was dropped April 3, 1926, and is therefore five years old. Records

indicate that she herself was a single lamb. The sire of the six lambs was "Matthews 139," (A.R.D. 2021) a ram imported by Dr. Brownell from New Zealand. The same ram also sired all of the ewe's previous lambs.

The sexes of the sextette were evenly divided, three rams and three ewes. Birthweights were not obtained; but on March 20, when the lambs were about 49 hours old, they were weighed. Three of the lambs, being artifically fed, had received no milk for 3 hours previous to weighing; the other two were with the ewe. It is probable that the weights given here are very close to the birthweights. These weights were:

♂ 7 lbs.	5½ lbs.
♂ 5¾ lbs.	6¼ lbs.
♂ p¾ lbs.	4 lbs.*

Considering the weight of the dead lamb to be 4 pounds, the combined birthweight of all 6 was about 35 pounds. Records of birthweights of Romney lambs in the University of California flock show that singles usually weight about 10 pounds and twins 8 to 8.5 pounds each.

As to the authenticity of this case, there can be little doubt. Mr. William R. Hosselkus, superintendent of the ranch, is a graduate of the University of California, known intimately to one of the undersigned and is highly respected for his veracity on all occasions. He and Allister Nicholson, experienced shepherd, had rather anticipated that the ewe might have quadruplets, so enormous was her barrel before lambing. Although other ewes were in the same field at the time, none lambed within several hours before or after No. 3866. When the ewe was discovered, she had isolated herself and already had two lambs. That these were her own is attested by Mr. Hosselkus' written statement: "When we found this ewe in the field she was licking the two lambs. Parts of the umbilical cords were hanging from her vulva, and the wool on her posterior was smeared with yolk." Then in the presence of Hosselkus and Nicholson the ewe gave birth to three more lambs. The men went to the barn, returning within 30 minutes to find the sixth lamb.

*This lamb died. The weight of it is an estimate only. It was dropped as No. 4 in the series. The 7 pound lamb was dropped 5th.

Body and Mind

(*Continued from page* 216)

Pearson: "Let us admit finally that the mind of man is for the most part a congenital product, and the factors which determine it are racial and familial; we are not dealing with a mutable characteristic capable of being moulded by the doctor, the teacher, the parent or the home environment. These may provide the material upon which it can act, and give a welcome scope for its activities, but they do not create it."

This seems to be an admission by a professor of psychology that individual differences in intellect should hereafter be best studied by biologists rather than by psychologists.

JOSEPH ROSSMAN.